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ABSTRACT

To gather information for its response to the issue whether to allow the use of hand-held calculators on standardized mathematics tests, the staff at Educational Testing Service (ETS), under the sponsorship of the College Board, developed a questionnaire to poll teachers of college-level mathematics about calculator and microcomputer use in freshman mathematics courses. Four copies of the questionnaire were sent to the mathematics department chair in each of 392 colleges throughout mainland United States, Hawaii, and Puerto Rico. Respondents indicated a moderate use of the calculator in college mathematics courses. For instance, in approximately 40 percent of the courses represented, a calculator is needed for some of the homework. Calculator use is noticeably higher in the statistics courses than in other courses. Computers are not used in college mathematics classes as much as calculators are. Respondents varied greatly in their opinions about whether the use of calculators should be allowed on College Board mathematics examinations. Appendices include the survey questionnaire, summary of responses, comments, and a list of participating institutions. (YP)

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College Board
Report
No. 88-6

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A Survey of the Use of Hand Calculators and Microcomputers in College Mathematics Classes

Jane L. Kupin
Beverly R. Whittington

A Survey of the Use of Hand Calculators and Microcomputers in College Mathematics Classes

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College Board Report No. 88-6

ETS RR No. 88-9

College Entrance Examination Board, New York, 1988

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Acknowledgments

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INTRODUCTION

To gather information for its response to the issue whether to allow the use of hand-held calculators on standardized mathematics tests, the staff at Educational Testing Service (ETS), under the sponsorship of the College Board, developed a questionnaire to poll teachers of college-level mathematics about calculator and microcomputer use in freshman mathematics courses. The questionnaire, sent to college mathematics departments, asked faculty members to describe the extent to which students in their courses use calculators and microcomputers and to register their opinions about allowing students to use these instruments on the Mathematics Achievement Tests and the Advanced Placement Examinations in Mathematics of the College Board.

PROCEDURE

Four copies of the questionnaire were sent to the mathematics department chair in each of 392 colleges throughout mainland United States, Hawaii, and Puerto Rico.

Since the results of the survey will be used to help determine the appropriateness of calculator use on the Mathematics Achievement Tests, it was decided to include all colleges that require College Board Achievement Test scores of entering students. There are 150 colleges in this category. (This group of colleges will be referred to as group I.) The remaining 242 colleges were chosen at random from among all colleges that do not require College Board Achievement Test scores but do receive such scores from at least 24 prospective students. (This group of colleges will be referred to as group II.)

The questionnaires were mailed to the colleges in early April 1987 with a requested return date of May 1 (see Appendix 1b). A follow-up postcard (see Appendix 1c) extended the deadline to May 15.

Of the 1,568 questionnaires sent to 392 colleges, 477 from 183 colleges were filled out and returned. Of the 477 returned questionnaires, 180 came from faculty members of 72 colleges in group I and 297 came from faculty members of 111 colleges in group II. Although the response rate was below 50 percent—48 percent for group I institutions and 46 percent for group II institutions—the respondents are representative of the institutions polled. Of the 42 states represented in the sample, responses were received from institutions in 37, in addition to the District of Columbia and Puerto Rico. Four-year public and private institutions were represented, as well as a few two-year public institutions.

In general, the two groups responded in similar ways, but some variation between the groups was observed in the answers to question 6 of part I, which refers to the use of calculators on College Board examinations. This variation is discussed in the Results section of the report.

The responses to questions 1, 2, 3, 4, 6, and 7 of part I and questions 1, 2, 3, 4, and 7 of part II were keyed in by personnel in Data Entry Systems and then downloaded to a microcomputer and analyzed by use of Lotus 1-2-3. Question 8 of part I and question 8 of part II were tallied by hand. The comments and lists were read and compiled by a member of the mathematics staff.

RESULTS

The tabulated results from the completed questionnaires can be found in Appendix 2. A discussion of the responses to each question follows.

Part I. Calculators

Question 1. Check all courses that you teach to *freshmen.*

Approximately 90 percent of all respondents teach calculus, and about 60 percent teach elementary functions. The approximate percentages for the other courses are 40 percent for both college algebra and non-calculus-based statistics, 30 percent for both linear algebra and discrete mathematics, and 10 percent for calculus-based statistics. The percentages total more than 100 because the respondents were asked to check all courses they teach to freshmen.

The total number of respondents teaching each course is shown above the name of the course in the summary in Appendix 2 for question 3 of part I and questions 1 and 2 of part II. The total for each course was used as the base of the percentage for that course in the summary for questions 2, 3, and 4 of part I and questions 1 and 2 of part II.

Question 2. Specify the type(s) of calculators used by students in each course checked in #1. Put an N if calculators are *not* allowed in the course.

The lowest response rate for this question was 79 percent for the teachers of discrete mathematics. The majority of response rates were in the 90s.

The percentages indicating some calculator use ranged from 71 percent to 97 percent; the lowest was from the teachers of discrete mathematics and the highest was from the statistics (calculus-based) teachers. The results show that the scientific calculator is used in more courses than are the other types of calculators.

In the summary for question 2 in Appendix 2, Part I, four numbers are shown for each course. The first is

the number of responses indicating at least some calculator use in the course (i.e., the total of responses A through E, including combinations of letters). The second entry is the first number written as a percentage of the total for that course. The third is the number of Ns; the fourth is the number of blanks. A separation of the first number into its parts (showing the numbers of responses for each letter or combination of letters) is given in Appendix 3.

Questions 3 and 4. For each of the mathematics courses listed that you teach, check the boxes that describe the use of hand calculators in your classes. (Check all that apply.)

Question 3. Hand calculators are

a. not required at all.
b. necessary for use in doing some homework.
c. allowed but not required during some tests.
d. required during some tests.
e. *not* permitted on any tests.

The numbers of checks recorded for each course in answer to this question and the percentages of the total for that course are given in the boxes for question 3 in Appendix 2, Part I. Some of the results are a little difficult to understand. For instance, it would be reasonable to expect the percentages in rows (*a*) and (*b*) of any column to add to 100 percent, but in one column they add to more than 100 percent. Also, it would be reasonable to expect the percentages in rows (*c*), (*d*), and (*e*) of any column to add to 100 percent or more, but in several columns the total is less than 100 percent.

As one might expect, the subject for which calculators are usually necessary for homework is statistics. It is interesting to note that over 50 percent of the teachers in all subjects allow calculators to be used during some tests, and fewer than 30 percent responded that calculators were *not* permitted on any tests.

Question 4. Which statements below describe the policy you have regarding instruction in the use of hand calculators?

a. Some class time is devoted to showing students how to use calculators.
b. The course is modified to include topics that are particularly suited to the use of the hand calculator.

The percentage of respondents indicating that they devote some class time to calculator instruction ranges from a high of 42 percent (in elementary functions) to a low of 6 percent (in linear algebra). Generally, few respondents (below 25 percent) indicate that they modify their courses to include topics particularly suited to the use of calculators.

Both the numbers of checks recorded for each course and their percentage of the total for that course are given in the boxes for question 4 in Appendix 2, Part I.

Question 5. Please list the topics that are particularly suited to the use of the calculator.

The list includes topics from most freshman college mathematics courses, with the greatest use in trigonometry, limits, integration, and basic statistical computations (means, standard deviation, etc.).

Of the 477 questionnaires tallied, 357 (75 percent) responded to this question. The topics are listed in Appendix 4.

Question 6. What is your opinion about the use of calculators on the following College Board examinations?

a. Mathematics Level I Achievement Examination[1]
  i. Calculators should not be allowed.
  ii. Calculators should be allowed, but not required.
  iii. Calculators should be required for some questions.
  iv. No opinion.

b. Mathematics Level II Achievement Examination. (same choices i–iv as above)

c. Advanced Placement Calculus AB Examination (same choices i–iv as above)

d. Advanced Placement Calculus BC Examination (same choices i–iv as above)

In the summary for question 6 (Appendix 2, Part I), the number of checks recorded is given as well as the percentages, using 477 (the total faculty responses) as the base. Opinion seems to be divided on whether it is a good idea for students to use calculators on the two College Board Mathematics Achievement Tests (Level I and Level II) or on the two College Board Advanced Placement Calculus Examinations (Calculus AB and Calculus BC).

If the number of respondents choosing (ii) (Calculators should be allowed, but not required) and (iii) (Calculators should be required for some questions) are added, signifying the total votes in favor of calculator use, and are compared with the number of respondents choosing (i) (Calculators should not be allowed), the results are as follows:

1. In the questionnaire, the Achievement Tests were referred to as Achievement Examinations. The exact wording of the questionnaire entries is preserved, but elsewhere in this report the Achievement Tests are referred to appropriately as "tests."

Mathematics Level I Achievement Examination

i.	207	43%
ii. or iii.	192	40%

Mathematics Level II Achievement Examination

i.	177	37%
ii. or iii.	216	45%

Advanced Placement Calculus AB Examination

i.	161	34%
ii. or iii.	253	53%

Advanced Placement Calculus BC Examination

i.	162	34%
ii. or iii.	253	53%

The vote seems to go slightly against allowing calculators on the Level I Mathematics Achievement Test, slightly in favor of allowing calculators on the Level II Mathematics Test, and strongly in favor of allowing calculators on the two Advanced Placement Calculus Examinations.

Among those respondents favoring the use of calculators on College Board examinations, a clear majority prefer making calculator use optional—choice (ii). This option, however, was singled out as unfair in some of the comments given in answer to question 7.

The two groups of respondents described earlier in this report showed some difference in their answers to question 6. Those in group I (faculty members of colleges that require College Board Achievement Test scores) were a little more likely to oppose the use of calculators on these tests than were those in group II (faculty members of colleges that do not require Achievement Test scores but received scores from at least 24 prospective students). Also, respondents in group I were less likely to leave this question blank than were those in group II. The percentages for the two groups are shown below.

		Group I percentages (total 180)	*Group II percentages (total 297)*
6*a*	i.	48%	40%
	ii.	28	33
	iii.	9	9
	iv.	13	14
	blank	1	4
6*b*	i.	43	34
	ii.	30	34
	iii.	12	13
	iv.	13	14
	blank	2	5
6*c*	i.	39	31
	ii.	34	38
	iii.	16	17
	iv.	9	10
	blank	1	4
6*d*	i.	39	31
	ii.	35	38
	iii.	16	16
	iv.	9	10
	blank	1	5

Question 7. Do you have any concerns about the use of calculators on standardized tests in general? (Comments were invited.)

Of the 477 questionnaires tallied, 437 (92 percent) contained comments in answer to this question. Concerns included a general trend toward overuse of calculators by students, the effect of calculator use on the examinations, problems of inequity, and practical problems (such as an opportunity to cheat). Comments were also made in favor of calculator use on standardized tests, as well as comments favoring modified use.

In the summary for question 7 in Appendix 2, part I, the numbers of responses for Yes, No, and Blank are given, as well as percentages of the total. A list of the comments made in answer to this question is given in Appendix 5.

Question 8. Are you interested in writing multiple-choice questions in precalculus mathematics for which calculators can be effectively used and/or are calculator-dependent?

Of the 477 respondents, 62 (13 percent) indicated an interest in writing such questions.

Part II. Microcomputers

The following code was given for question 1:

0—Not at all
1—Less than one-third of the time
2—Between one-third and two-thirds of the time
3—More than two-thirds of the time

Question 1. For each course, using the code above, mark the boxes to indicate how microcomputers are used in your classes. (Please mark all boxes for the courses that apply.)

a. Drill and practice
b. Word processing
c. Simulations of real-life situations
d. Analysis of data
e. Working through teacher-written programs
f. Programming by students
g. If used for (f), in what language?
h. By the teacher to augment lectures
i. Instruction and remediation
j. Other _____

The response to question 1 indicates a moderate use of microcomputers in college mathematics classes. The highest use (60 percent) was for the analysis of data

in the calculus-based statistics classes. In courses other than statistics, there were no positive response rates above 20 percent.

In the summary for question 1 (Appendix 2, part II), two numbers appear in each box. The first number is the total of all responses indicating some use of microcomputers for that course and in that category. That is, it gives the total of responses 1, 2, or 3 for that box. The second number is the first written as a percentage of the total for that course. A complete list of responses to this question is given in Appendix 6.

Question 2. Indicate by checking the appropriate boxes those courses that have been modified to include topics that are particularly suited to the use of the computer.

The percentages of positive responses to this question range from 20 percent (in college algebra) to 53 percent (in calculus-based statistics).

For each course, the number of checks recorded is given in the summary for question 2 (Appendix 2, Part II), followed by that number expressed as a percentage of the total for that course.

Question 3. If microcomputers are used in your classes, is any class time devoted to teaching or assisting students in the use of the computer?

Of the 59+ percent of the respondents who answered this question, the majority indicated that class time is not devoted to showing students how to use the computer.

For both questions 3 and 4, the numbers of Yes and No responses and numbers of blanks are given in the summary in Appendix 2, Part II, followed by the number expressed as a percentage of the total, 477.

Question 4. Are there special classes devoted to instruction in the use of microcomputers?

Respondents indicated some availability of computer instruction in special classes; i.e., 45 percent responded Yes.

Question 5a. What microcomputer makes and models are available at your school for student use?

Of the 447 respondents, 82 percent answered this question. A list of the microcomputers named is given in Appendix 7.

Question 5b. What applications packages do you use?

Only 42 percent of the respondents answered this question. A list of the software packages named is given in Appendix 8.

Question 6. Please list the topics that are particularly suited to the use of the microcomputer.

Of the 477 respondents, 58 percent answered this question. The topics named most frequently are limits, numerical differentiation and integration, graphing, approximation of roots, linear algebra, and statistics computations.

A list of the topics named is given in Appendix 9.

Question 7. Are there mathematical skills that you believe can be assessed using computer simulations that cannot be assessed using paper and pencil tests? Please explain.

The response rate for this question was 88 percent. Most responses were divided evenly between No and No Opinion. Fewer than 20 percent answered Yes. The comments reinforce the responses. There was not a strong belief that there are such skills.

In the summary for question 7 (Appendix 2, Part II), the numbers of Yes and No responses and their percentages are given. The comments made in answer to "Please explain" are listed in Appendix 10.

Question 8. Would you like to receive a copy of the questionnaire results?

Over 60 percent of the respondents indicated that they would like to receive the results. This indicates a moderate interest in the issue of technology in assessment.

In the summary for question 8 in Appendix 2, Part II, the numbers of responses and their percentages are given.

CONCLUSIONS

Respondents indicated a moderate use of the calculator in college mathematics courses. For instance, in approximately 40 percent of the courses represented, a calculator is needed for some of the homework. (The weighted average of the percentages given in row (b) for question 3 of part I is 40 percent.) Calculator use is noticeably higher in the statistics courses than in other courses. Computers are not used in college mathematics classes as much as calculators are.

Respondents varied greatly in their opinions about whether the use of calculators should be allowed on College Board mathematics examinations. Strong comments were made both in favor of and against authorizing their use. There does not seem to be a strong push by the teachers of mathematics courses taken by college freshmen to permit calculators to be used on the College Board's examinations. Nor does there seem to be evidence that freshman mathematics courses have been changed to a great extent by technology.

APPENDIX 1a. TECHNOLOGY SURVEY

EDUCATIONAL TESTING SERVICE PRINCETON, N.J. 08541

TECHNOLOGY SURVEY

1987

(College)

Please RETURN THIS QUESTIONNAIRE by May 1, 1987 to:

Beverly R. Whittington, 25-E, Educational Testing Service, Princeton, NJ 08541

TECHNOLOGY SURVEY
1987
(College)

Part I. CALCULATORS

The College Board and the Educational Testing Service have been discussing the advisability of using calculators during the administration of some of its mathematics examinations. As background information for these discussions, they would like to ascertain the extent and nature of calculator use among college freshman mathematics students. To this end, they would appreciate your cooperation in completing the following questionnaire.

*For this survey, calculators are divided into four types:

A. Basic. Arithmetic functions only.

B. Scientific. Includes trigonometric and exponential functions.

C. Statistical.

D. Programmable.

E. All of the above

1. Check all courses that you teach to freshmen. (Including Advanced Placement students.)

2. Using the code* above, specify the type(s) of calculators used by students in each course checked in #1. Put an N if calculators are not allowed in the course.

	Courses						
	College Algebra	Elementary Functions (Precalculus and/or Trigonometry)	Statistics (Non-Calculus-based)	Statistics (Calculus-based)	Calculus	Discrete Mathematics	Linear Algebra

Questions 3 and 4

For each of the mathematics courses listed that you teach, check the boxes that describe the use of hand calculators in your classes. (Check all that apply.)

3. Hand calculators are

   a. not required at all.

   b. necessary for use in doing some homework.

   c. allowed but not required during some tests.

   d. required during some tests.

   e. NOT permitted on any tests.

4. Which statements below describe the policy you have regarding instruction in the use of hand calculators?

   a. Some class time is devoted to showing students how to use calculators.

   b. The course is modified to include topics that are particularly suited to the use of the hand calculator.

	Courses						
	College Algebra	Elementary Functions (Precalculus and/or Trigonometry)	Statistics (Non-Calculus-based)	Statistics (Calculus-based)	Calculus	Discrete Mathematics	Linear Algebra
3a							
3b							
3c							
3d							
3e							
4a							
4b							

5. Please list the topics that are particularly suited to the use of the calculator.

_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

6. What is your opinion about the use of calculators on the following College Board Examinations?

a. Mathematics Level I Achievement Examination

____ i. Calculators should not be allowed.
____ ii. Calculators should be allowed, but not required.
____ iii. Calculators should be required for some questions.
____ iv. No opinion.

b. Mathematics Level II Achievement Examination

____ i. Calculators should not be allowed.
____ ii. Calculators should be allowed, but not required.
____ iii. Calculators should be required for some questions.
____ iv. No opinion.

c. Advanced Placement Calculus AB Examination

____ i. Calculators should not be allowed.
____ ii. Calculators should be allowed, but not required.
____ iii. Calculators should be required for some questions.
____ iv. No opinion.

c. Advanced Placement Calculus BC Examination

____ i. Calculators should not be allowed.
____ ii. Calculators should be allowed, but not required.
____ iii. Calculators should be required for some questions.
____ iv. No opinion.

7. Do you have any concerns about the use of calculators on standardized tests in general?

Yes ____ No ____

Comments: _____

_____

_____

_____

_____

8. Are you interested in writing multiple-choice test questions in precalculus mathematics for which calculators can be effectively used and/or are calculator-dependent?

Yes ____ No ____

Part II. MICROCOMPUTERS

The College Board and the Educational Testing Service are also interested in gathering information about the use of microcomputers in college freshman mathematics and science classes.

*Please use the following code to answer question 1.
0 - Not at all
1 - Less than one-third of the time
2 - Between one-third and two-thirds of the time
3 - More than two-thirds of the time

1. For each course, using the code* above, mark the boxes to indicate how microcomputers are used in your classes. (Please mark all boxes for the courses that apply.)

	Courses						
	College Algebra	Elementary Functions (Precalculus and/or Trigonometry)	Statistics (Non-Calculus-based)	Statistics (Calculus-based)	Calculus	Discrete Mathematics	Linear Algebra
a. Drill and Practice							
b. Word Processing							
c. Simulations of real-life situations							
d. Analysis of data							
e. Working through teacher-written programs							
f. Programming by students							
g. If used for (f), in what language?							
h. By the teacher to augment lectures							
i. Instruction and remediation							
j. Other _____							
2. Indicate by checking the appropriate boxes those courses that have been modified to include topics that are particularly suited to the use of the computer.							

3. If microcomputers are used in your classes, is any class time devoted to teaching or assisting students in the use of the computer?

Yes ____ No ____

4. Are there special classes devoted to instruction in the use of microcomputers?

Yes ____ No ____

5. a. What microcomputer makes and models are available at your school for student use?

_____ _____

_____ _____

b. What applications packages do you use?

_____ _____

_____ _____

6. Please list the topics that are particularly suited to the use of the microcomputer.

_____ _____

_____ _____

_____ _____

7. Are there mathematical skills that you believe can be assessed using computer simulations that cannot be assessed using paper and pencil tests?

Yes ____ No ____ No opinion ____

Please explain: _____

_____

_____

8. Would you like to receive a copy of the questionnaire results?

Yes ____ No ____

Questionnaire completed by _____
(Optional) Signature

_____
(Optional) Name (please print)

Title _____

Institution _____ College Code # / / / / /

Address _____

City, State, Zip _____

Please RETURN THIS QUESTIONNAIRE by May 1, 1987 to:

Beverly R. Whittington, 25-E, Educational Testing Service, Princeton, NJ 08541

APPENDIX 1b. COVERING LETTER

EDUCATIONAL TESTING SERVICE PRINCETON, N.J. 08541

April 1, 1987

Dear Mathematics Department Chair:

The rapid increase in use of electronic calculators and microcomputers by students and the general population has posed serious questions for standardized test makers. How has the mathematics curriculum been changed by these devices? And, should the use of calculators be allowed on standardized tests? The College Board's Mathematical Sciences Advisory Committee would like to obtain the response of you and your Mathematics Department colleagues to these and other pertinent questions.

The Advisory Committee is aware of the availability to students of calculators and microcomputers. At this time, however, the use of calculators or other devices is not permitted in the examination room during the testing period when the College Board's Mathematics Achievement Examinations and Advanced Placement Calculus Examinations are given.

Periodically the Committee evaluates its position on such important issues and will be discussing this issue and making recommendations to the College Board. In order to arrive at an informed and reasonable policy concerning the use of calculators in the future, the Committee hopes that you and three of your colleagues in the Mathematics Department will complete and return the enclosed questionnaires by May 1, 1987 in the envelope provided. We may wish to list, in a report of the results, the names of the schools that participate in this survey, but we will not identify specific results by school.

We hope you will agree to participate in this survey, and we will be happy to share the results with you. Thank you for your time and effort in this endeavor.

Sincerely,

Jeremy Kilpatrick /jmm

Jeremy Kilpatrick, Chairman
Mathematical Sciences Advisory Committee
Professor, University of Georgia

/jmm

Enclosures

APPENDIX 1c. FOLLOW-UP POSTCARD

Last month a survey on calculator and computer use in college mathematics courses was mailed to your department, but so far no response has been received from your institution. The survey was sponsored by the College Board Mathematical Sciences Advisory Committee and the questionnaire included questions on the use of calculators on national standardized tests. The experiences and opinions of all the faculty at the colleges in the sample are valued, so the deadline for returning questionnaires has been extended to May 15. If you no longer have the questionnaires and still wish to respond to the survey, you may call collect to Mrs. Beverly Whittington (609) 734-1299 to receive additional questionnaires. Thank you for your attention.

EDUCATIONAL TESTING SERVICE PRINCETON, N.J. 08541

TECHNOLOGY SURVEY

1987

(College)

Please RETURN THIS QUESTIONNAIRE by May 1, 1987 to:

Beverly R. Whittington, 25-E, Educational Testing Service, Princeton, NJ 08541

TECHNOLOGY SURVEY
1987
(College)

Part I. CALCULATORS

The College Board and the Educational Testing Service have been discussing the advisability of using calculators during the administration of some of its mathematics examinations. As background information for these discussions, they would like to ascertain the extent and nature of calculator use among college freshman mathematics students. To this end, they would appreciate your cooperation in completing the following questionnaire.

*For this survey, calculators are divided into four types:

A. Basic. Arithmetic functions only.

B. Scientific. Includes trigonometric and exponential functions.

C. Statistical.

D. Programmable.

E. All of the above

		Courses						
		College Algebra	Elementary Functions (Precalculus and/or Trigonometry)	Statistics (Non-Calculus-based)	Statistics (Calculus-based)	Calculus	Discrete Mathematics	Linear Algebra
1. Check all courses that you teach to freshmen. (Including Advanced Placement students.)		212	274	206	58	426	140	165
		44%	57%	43%	12%	89%	29%	35%
2. Using the code* above, specify the type(s) of calculators used by students in each course checked in #1. Put an N if calculators are not allowed in the course.	Some Use	164	234	194	56	356	87	133
		77%	85%	94%	97%	84%	62%	81%
	N	37	30	3	4	52	12	19
	Blank	276	213	280	417	69	378	325

For a detailed list of responses to question 2, see Appendix 3.

Questions 3 and 4
For each of the mathematics courses listed that you teach, check the boxes that describe the use of hand calculators in your classes. (Check all that apply.)

	Courses						
	212 College Algebra	274 Elementary Functions (Precalculus and/or Trigonometry)	206 Statistics (Non-Calculus-based)	58 Statistics (Calculus-based)	426 Calculus	140 Discrete Mathematics	165 Linear Algebra
3. Hand calculators are							
a. not required at all.	115 54%	98 36%	44 21%	19 33%	176 41%	71 51%	101 61%
b. necessary for use in doing some homework.	59 28%	117 43%	125 61%	47 81%	160 38%	44 31%	44 27%
c. allowed but not required during some tests.	114 54%	144 53%	105 51%	44 76%	257 60%	99 71%	119 72%
d. required during some tests.	31 15%	81 30%	98 48%	30 52%	70 16%	18 13%	18 11%
e. NOT permitted on any tests.	52 25%	38 14%	6 3%	3 5%	78 18%	17 12%	28 17%
4. Which statements below describe the policy you have regarding instruction in the use of hand calculators?							
a. Some class time is devoted to showing students how to use calculators.	61 29%	115 42%	70 34%	12 21%	75 18%	15 11%	10 6%
b. The course is modified to include topics that are particularly suited to the use of the hand calculator.	20 9%	46 17%	40 19%	14 24%	70 16%	20 14%	22 13%

5. Please list the topics that are particularly suited to the use of the calculator.

131 respondents, 27% of the total, left this blank.
8 respondents, 2% of the total, answered None.
1 respondent answered Many.
357 respondents, 75% of the total, listed one or more topics; these topics are given in Appendix 4.

6. What is your opinion about the use of calculators on the following College Board Examinations?

a. Mathematics Level I Achievement Examination

207 (43%) i. Calculators should not be allowed.
148 (31%) ii. Calculators should be allowed, but not required.
44 (9%) iii. Calculators should be required for some questions.
78 (16%) iv. No opinion.

b. Mathematics Level II Achievement Examination

177 (37%) i. Calculators should not be allowed.
155 (32%) ii. Calculators should be allowed, but not required.
61 (13%) iii. Calculators should be required for some questions.
84 (18%) iv. No opinion.

c. Advanced Placement Calculus AB Examination

161 (34%) i. Calculators should not be allowed.
174 (36%) ii. Calculators should be allowed, but not required.
79 (17%) iii. Calculators should be required for some questions.
63 (13%) iv. No opinion.

c. Advanced Placement Calculus BC Examination

162 (34%) i. Calculators should not be allowed.
175 (37%) ii. Calculators should be allowed, but not required.
78 (16%) iii. Calculators should be required for some questions.
62 (13%) iv. No opinion.

7. Do you have any concerns about the use of calculators on standardized tests in general?

Yes 249 (52%) No 212 (44%) Blank 16 (3%)

Comments: 40 respondents, 8% of the total, left the comment section blank. 437 respondents, 92% of the total, made at least one comment; these comments are listed in Appendix 5.

8. Are you interested in writing multiple-choice test questions in precalculus mathematics for which calculators can be effectively used and/or are calculator-dependent?

Yes 62 (13%) No 401 (84%) Blank 14 (3%)

Part II. MICROCOMPUTERS

Question 1. In the summary only two numbers appear in each box. For this question the first number is the total of responses 1, 2, or 3, each indicating at least some use of microcomputers in the course. The second number is the first number as a percentage of the total for that course. The full list of responses for each course is given in Appendix 6.

1. For each course, using the code* above, mark the boxes to indicate how microcomputers are used in your classes. (Please mark all boxes for the courses that apply.)

	Courses						
	212 College Algebra	274 Elementary Functions (Precalculus and/or Trigonometry)	206 Statistics (Non-Calculus-based)	58 Statistics (Calculus-based)	426 Calculus	140 Discrete Mathematics	165 Linear Algebra
a. Drill and Practice	35(17)	34(12)	40(19)	18(31)	52(12)	14(10)	23(14)
b. Word Processing	6 (3)	5 (2)	9 (4)	6(10)	11 (3)	7 (5)	6 (4)
c. Simulations of real-life situations	7 (3)	15 (5)	40(19)	21(36)	43(10)	17(12)	20(12)
d. Analysis of data	4 (2)	12 (4)	76(37)	35(60)	25 (6)	7 (5)	15 (9)
e. Working through teacher-written programs	10 (5)	17 (6)	25(12)	19(33)	52(12)	21(15)	32(19)
f. Programming by students	5 (2)	9 (3)	16 (8)	11(19)	39 (9)	22(16)	23(14)
g. If used for (f), in what language?	--See Appendix 6b for languages--						
h. By the teacher to augment lectures	20 (9)	38(14)	54(26)	27(47)	122 (29)	30(21)	50(30)
i. Instruction and remediation	28(13)	30(11)	24(12)	13(22)	44(10)	7 (5)	13 (8)
j. Other _____	1(<1)	5 (2)	7 (3)	4 (7)	20 (5)	5 (4)	7 (4)
2. Indicate by checking the appropriate boxes those courses that have been modified to include topics that are particularly suited to the use of the computer.	43(20)	86(31)	74(36)	31(53)	123 (29)	33(24)	78(47)

3. If microcomputers are used in your classes, is any class time devoted to teaching or assisting students in the use of the computer?

Yes 126(26%) No 159(33%) Blank 192 (40%)

4. Are there special classes devoted to instruction in the use of microcomputers?

Yes 216(45%) No 189(40%) Blank 72(15%)

5. a. What microcomputer makes and models are available at your school for student use?

389 respondents, 82% of the total, listed models given in Appendix 7.

b. What applications packages do you use?

201 respondents, 42% of the total, listed applications (software) packages given in Appendix 8.

6. Please list the topics that are particularly suited to the use of the microcomputer.

278 respondents, 58% of the total, listed topics given in Appendix 9.

7. Are there mathematical skills that you believe can be assessed using computer simulations that cannot be assessed using paper and pencil tests?

Yes 92(19%) No 142(30%) No opinion 186(39%) Blank 57(12%)

Please explain: 128 respondents, 27% of the total, made comments given in Appendix 10.

8. Would you like to receive a copy of the questionnaire results?

Yes 299(63%) No 147(31%) Blank 31(6%)

Questionnaire completed by _____
(Optional) Signature

_____
(Optional) Name (please print)

Title _____

Institution _____ College Code # / / / / /

Address _____

City, State, Zip _____

Please RETURN THIS QUESTIONNAIRE by May 1, 1987 to:

Beverly R. Whittington, 25-E, Educational Testing Service, Princeton, NJ 08541

APPENDIX 3. SUMMARY OF RESPONSES TO QUESTION 2 OF PART I

Courses

	College Algebra	*Elementary Functions (Precalculus and/or Trigonometry)*	*Statistics (Non-calculus-based)*	*Statistics (Calculus-based)*	*Calculus*	*Discrete Mathematics*	*Linear Algebra*
A	26	6	22	2	5	8	5
B	54	124	25	13	158	33	50
C	0	0	34	8	1	1	0
D	0	0	0	0	1	1	2
A, B	25	17	6	3	27	14	12
A, C	0	0	2	0	0	0	0
A, B, C	1	2	17	1	4	1	1
A, B, D	1	4	1	0	12	6	6
B, C	0	0	19	4	2	4	0
B, D	6	6	0	0	19	1	3
B, C, D	0	2	2	0	4	0	0
C, D	0	0	1	0	0	0	1
E	51	73	63	23	123	44	52

Legend: A. Basic. Arithmetic functions only.
B. Scientific. Includes trigonometric and exponential functions.
C. Statistical.
D. Programmable.
E. All of the above.

APPENDIX 4. TOPICS PARTICULARLY SUITED TO THE USE OF THE CALCULATOR, IN RESPONSE TO QUESTION 5 OF PART I*

Algebra
squares, cubes, square roots, cube roots (15)
solving equations (12)
algebra (6)
quadratic equations (6)
prime factorization (4)
factorials (3)
scientific notation (3)
summation (2)
polynomial evaluation, remainder theorem (2)
algorithms (2)
linear interpolation
base conversions
algebra word problems

Business Mathematics
mathematics of finance (11)
compound interest (11)
annuities (2)
business

Elementary Functions
trigonometry (122)
logarithms and exponents (64)
evaluating functions (22)
solution of triangles (11)
transcendental functions (10)
inverse functions (4)
composition of functions
De Moivre's Theorem
finding the value of *e*
understanding the difference between log and ln

Precalculus
limits (55)
graphing (29)
series (27)
sequences (9)
polar coordinates (5)
asymptotes
slopes
difference quotients

Calculus
integration (90)
calculus applications (33)
Simpson's rule (27)
power series (19)
numerical methods and numerical analysis (17)
differentiation (15)
Riemann sums (9)
differential equations (7)
max/min problems (2)
Intermediate Value Theorem
differentials

Linear Algebra
matrix algebra (7)
matrices—row reduction (3)
determinants (3)
matrix inverses (2)
vectors (2)
eigenvalue problems

Probability/Statistics
probability (18)
permutations and combinations (17)
counting problems (4)
binomial coefficient (2)
random number generator

Statistics
basic statistical computations (means, standard deviation, etc.) (127)
regression and correlation (21)
all topics in statistics (18)
hypothesis testing (14)
confidence intervals (9)
chi-squares (3)
Poisson distributions (3)
statistical inference (3)
error estimation (2)
analysis of variance (2)
Monte Carlo methods
smoothing
elementary forecasting
population parameters
paired samples
time series
index numbers
z-scores
distributions
nonstandard normal distribution

Computer Science
iterative procedures (6)

Miscellaneous
any topic in which numerical calculation inhibits the exploration of nontrivial cases (27)
arithmetic (17)
approximation (12)
estimation (2)
experimentation
any topic with calculator-friendly algorithms
operations research
learning the limits of the calculator

Other Subjects
economics
physics

*The number in parentheses indicates the number of times the topic was mentioned, if mentioned more than once.

APPENDIX 5. COMMENTS ON CALCULATOR USE*

Inequity

Calculators may give some students an advantage on tests because not all students can afford calculators, or because some can afford better calculators than others, or because some have had more experience with the type of calculator used on the test. (73)
Allowing, but not requiring, calculators is unfair. (7)

General Trend toward Overuse of Calculators

In general, students tend to use calculators too much or inappropriately. (28)
Students tend to lose computation skills and number sense. (13)
Calculators are misleading because they give inexact answers in a form that looks exact (e.g., $\sqrt{2}$ = 1.4142). (8)
Students may waste time on examinations because of inappropriate use of calculators and "dumb" errors. (7)
Students tend to lose the ability to estimate answers and to judge the reasonableness of answers. (6)
Calculators should *not* be allowed. (4)
Students may lose basic understanding.

The Effect of Calculators on the Examinations

Exams should test mathematics understanding, not calculator facility. (25)
Some calculators are too powerful. (20)
Some topics, such as inverse trigonometric functions, might have to be omitted. (15)
Calculator use on tests does not add to the information given by the test. (4)
Exams would have to be rewritten and equated with the older forms. (3)
Exams might include questions that have a heavy computational element. (2)
Calculator proficiency does not correlate with success in college mathematics. (2)
Good questions will be hard to write. (2)
Calculator use on tests may conceal skill deficiencies.

Practical Problems

Calculators might increase the opportunity to cheat. (16)
Proctors may have trouble controlling the use of calculators. (4)
Calculators might break down unexpectedly during the test. (2)

Comments in Favor of Allowing Calculators

Calculators are part of modern life (a tool, like a pencil or a watch), and we should use their power. (14)
Calculators improve students' performance on tests. (5)
Calculators are now inexpensive. (4)
Calculator skill should be rewarded. (3)
Calculators should be allowed because students taking tests should be in their normal problem-solving environment. (2)
Calculators allow tests to have more realistic problems. (2)
Emphasize concepts and allow students to choose their approach, including the use of calculators. (2)
No opinion on these [College Board] exams, but generally approve of calculator use on tests. (2)
College freshmen are expected to use calculators routinely.
Calculators allow testing of concepts, because the tests will no longer test arithmetic.
Calculators aid in the development of "reasonableness" of answers.

Comments in Favor of Modified Use of Calculators on Tests

Calculators are all right once the student shows skill in arithmetic (including fractions). (7)
Calculators are all right as long as what's being tested isn't just calculation. (7)
Calculators should be allowed only if the multiple-choice format is dropped.

Other Comments, Some for and Some against Allowing Calculators

Use of calculators on tests may adversely affect the high school curriculum. (4)
Lack of calculators on tests may adversely affect the high school curriculum. (2)
Calculators give students a false sense of security on tests. (2)
Calculators might be appropriate for nonmathematics College Board Achievement Tests. (2)
Calculators give students comfort on tests.
If [other subjects] can, math can [use calculators], too.

Suggestions

Construct questions so that calculators are not needed on the test. (28)
Construct questions so that calculators will be needed on the test. (14)

*The number in parentheses indicates the number of times the comment was made, if it was made more than once.

Construct questions so that they are no easier for the sophisticated calculators than for the ordinary ones.

Allow scientific, but not programmable, calculators. (7)

If calculators are allowed, exams should not test specifically for calculator skill. (6)

There could be a separate test to assess calculator and/or computer skill. (2)

Allow only basic calculators. (2)

Publish the type and model of calculator allowed prior to the test.

Since allowing calculators might lead to inappropriate use (on elementary problems), but not allowing calculators might prohibit certain complex problems, the test might have to be divided into two parts, with calculators allowed on one part only.

Bypass calculators and go straight to computers.

APPENDIX 6a. DETAILED SUMMARY OF RESPONSES TO QUESTION 1 OF PART II

Codes used to answer question 1:

0—Not at all
1—Less than one-third of the time
2—Between one-third and two-thirds of the time
3—More than two-thirds of the time

		Courses						
		College Algebra	*Elementary Functions (Precalculus and/or Trigonometry)*	*Statistics (Non-calculus-based)*	*Statistics (Calculus-based)*	*Calculus*	*Discrete Mathematics*	*Linear Algebra*
a. Drill and practice	0	123	146	101	39	233	83	90
	1	34	33	35	16	49	14	20
	2	1	1	5	2	3	0	2
	3	0	0	0	0	0	0	1
b. Word processing	0	128	154	114	49	243	76	87
	1	4	4	6	6	8	6	5
	2	1	1	2	0	2	1	1
	3	1	0	1	0	1	0	0
c. Simulations of real-life situations	0	128	151	92	35	223	66	76
	1	6	14	34	19	42	17	20
	2	1	1	6	2	1	0	0
	3	0	0	0	0	0	0	0
d. Analysis of data	0	129	152	68	22	234	75	79
	1	4	12	55	25	24	7	15
	2	0	0	19	10	1	0	0
	3	0	0	2	0	0	0	0
e. Working through teacher-written programs	0	125	147	101	39	220	65	69
	1	9	16	19	12	51	19	31
	2	1	1	5	1	0	2	1
	3	0	0	1	6	1	0	0
f. Programming by students	0	130	153	111	43	223	66	78
	1	5	9	12	7	36	21	22
	2	0	0	3	4	3	1	1
	3	0	0	1	0	0	0	0
g. If used for (f), in what language?		—See Appendix 6b for list of languages—						
h. By the teacher to augment lectures	0	113	127	76	30	168	63	63
	1	19	38	44	21	116	27	46
	2	1	0	8	6	4	3	1
	3	0	0	2	0	2	0	3
i. Instruction and remediation	0	110	133	95	39	209	69	76
	1	26	27	21	11	41	6	12
	2	1	2	3	2	2	1	1
	3	1	1	0	0	1	0	0
j. Other _____ (See Appendix 6c for uses listed under "Other")	0	47	57	33	15	98	26	37
	1	1	3	5	3	17	5	7
	2	0	2	2	1	2	0	0
	3	0	0	0	0	1	0	0

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APPENDIX 6b. COMPUTER LANGUAGES GIVEN IN RESPONSE TO QUESTION 1g OF PART II*

College Algebra
Basic (5)

Elementary Functions
Basic (10)

Statistics (Non-Calculus-based)
Basic (10)
Pascal (5)
Mini tab (3)
Fortran
Mini exec
SPSS SAS

Statistics (Calculus-based)
Pascal (6)
Basic (2)
Fortran

Calculus
Basic (28)
Pascal (13)
Fortran (5)

Discrete Mathematics
Pascal (12)
Basic (8)
Fortran (3)

Linear Algebra
Pascal (12)
Basic (8)
Fortran (3)
student's choice

APPENDIX 6c. CLASSROOM USES OF MICROCOMPUTERS LISTED UNDER "OTHER"*

College Algebra
homework
problem solving

Elementary Functions
graphing (2)
problem solving
estimation
graphics
special software packages
lab explorations

Statistics (Non-Calculus-based)
special software packages (3)
as a terminal for mainframe (2)
problem solving
final project
graphics

Statistics (Calculus-based)
problem solving
graphics
special software packages
as a terminal for mainframe

Calculus
problem solving (3)
graphics (3)
experimental approach to functions and graphs (3)
symbolic manipulation (derivation and integration) (2)
demonstrations (2)
homework
series examples
separate calculus lab
special software packages
class management

Discrete Mathematics
problem solving
demonstrations
special software packages
class management

Linear Algebra
problem solving (2)
homework
graphics
special software packages
demonstrations
spreadsheet use with matrices

*The number in parentheses indicates the number of times the language was listed, if it was listed more than once.

APPENDIX 7. MICROCOMPUTERS NAMED IN RESPONSE TO QUESTION 5a OF PART II*

IBM PC (242)
IBM PC XT (26)
IBM PC AT (7)
IBM PC jr
IBM mainframe
IBM System II
IBM future
IBM compatibles (unspecified) (19)
IBM clones (unspecified) (19)
Apple (100)
Apple IIe (96)
Apple IIc (15)
Apple IIgs (2)
Apple Lisa
Macintosh (104)
MacPlus (10)
Apple compatibles (unspecified) (3)
Texas Instruments Professional (5)
Texas Instruments PC (3)
Zenith (23)
Zenith (IBM compatible) (5)
Zenith Telex (3)
Zenith Laptop
Z-158 (8)
Z-100 (5)
Z-148 (5)
Z-200 (3)
Z-248 (2)
Z-150
Tandy Radio Shack (11)
TRS 80 (17)
Vax (5)
Digital Vax mainframe (2)
Vax terminals
Vax 11/85
Vax 11/750
Vax 11/785
Microvax (6)
Vax-VMS-Gigi
Dec Rainbow (3)
Dec
Dec Vt 180
AT&T PC (24)
Leading Edge (10)
Commodore (7)
Amiga (6)
Compaq (5)
Epson (3)
Epson Equity II (2)
Kaypro (3)
ITT (3)
Fountain (3)
Terak (3)
Sun (3)
Toshiba (2)
NCR (2)
TTL
INNPC
Seabrook
Televideo
Wedge
Xerox
Volker Craig VC 415 Apl
Beltron
Phillips
Sanyo
Apollo
Atari 400
Burroughs

*The number in parentheses indicates the number of times the microcomputer was listed, if listed more than once.

APPENDIX 8. SOFTWARE PACKAGES NAMED IN RESPONSE TO QUESTION 5b OF PART II*

Miscellaneous

in-house packages (28)
packages accompanying textbooks (3)

Types of Software

graphing packages (13)
statistical packages (12)
word processing (8)
spreadsheets (7)
language compilers and interpreters (4)
calculus packages (3)
linear algebra (3)
graphics (3)
tutorial packages (2)
algebra packages (2)
database (2)
numerical methods
curves
linear programming
discrete mathematics
differential equations graphics

Specific Packages

(other than word processing)
Stat (80)
Mini Tab (25)
dBASE II, III, III+
(Maple) Mu Math (18)
Calculus Toolkit (11)
SAS (10)
SPSS (7)
Appleworks (6)
Arbplot (5)
Algebra Drill (4)
Calculus (Kemeny) (4)
SPSSX (4)
Statdisk (4)
Compucalc (3)
Multivariate Surfaces (3)
Abstat (2)
Algebra Arcade (2)
BMDP (2)
Cactus Plot (2)
Cal: The Mathematics Discovery Language (2)
Calc Lab (2)
Calculus Illustrated (2)
Calculus Pad (2)
Epic (2)
Flanders Microcalc (2)
Framework (2)
Gradebook Plus (2)
Key Stat (2)
Lin Stat (2)
Lin Pak (2)
Macsyma (2)
Microcalc (2)
Microsolve (2)
PC Math Lab (2)
Plato (2)
Reduce (2)
Remedial Math Drill and Practice (2)
Statview (2)
True Basic Calculus (2)
Advanced Graphics
Algebra without Anxiety
package accompanying Barnett's *Finite Mathematics*
Bridge Curves, Surfaces and Differentials
Bridge Math Utilities
Business and Economic Forecasting
Calc Aide (HBJ text package)
CLIM
Comp Stat
Computer Activities for Calculus
Computerstat
CTOS (Dec)
Discovery Learning in Trig
Eis Pak
Epistat
Excel
Exploring Calculus
Exploring Statistics with the IBM PC
Flanders Calculus
f(z)
Grossman Calc Supplement
Hands-on Statistics
IMSL
Interactive Experiments in Calculus (Apple)
Library
Linear Algebra Companion
Lin Tek
Lionheart Package (Amiga)
Mac Calculus
Manager
Matrix-aids
Matrix Pad
NW Stat
Oracle
PFS file
PFS Series
Private Tutor
Precalculus
Prof Calc
Probability and Statistics
Reflex
Stata
Stat Fast
Stat Pro
Statgraphics
Statistics with Finesse
Stat Works
package accompanying Thomas and Finney's *Calculus*
TK! Solver
T*Maker
software from True Basic, Inc.
True Basic—3D Graphics
True Stat
Turbo Graphics
Turbo Numeric Methods

Word Processing

WordPerfect (19)
WordStar (8)
T³ Scientific (3)
MacWrite (3)
Displaywrite (2)
Volkswriter (2)
Applewriter
Le Script
Microsoft Word
Ms-Word
PC Write
Perfect Writer
PFS Write
Scripsit
Volkswriter Scientific
Worditor

*The number in parentheses indicates the number of times the package was listed, if it was listed more than once.

APPENDIX 9. TOPICS PARTICULARLY SUITED TO THE USE OF THE MICROCOMPUTER, IN RESPONSE TO QUESTION 6 OF PART II*

Algebra

equations (7)
summation (4)
algebra (3)
factoring
polynomials
interpolation

Elementary Functions

trigonometry (5)
exponents and logarithms (5)
functions (3)
solving triangles

Calculus

graphing, including 3-dimensional graphs (109)
numerical differentiation and integration (87)
approximation of roots (Newton's method) (35)
limits (32)
symbolic differentiation and integration (20)
sequences and series (12)
power series (9)
area/volume (8)
tangent lines and definition of derivative (8)
polar graphs (6)
simulation of central limit theorem (5)
Riemann sums (5)
definition of integral (3)
calculus applications (3)
max/min (3)
Gaussian reduction (3)
asymptotes (2)
approximation algorithms in calculus (2)
calculus using symbolic algebra systems
fundamental theorem of integral calculus
law of large numbers
numerical techniques in calculus
Fourier series
multivariable calculus
multivariate functions
partial derivatives
elliptic integrals
vector calculus
surfaces
parametric equations
all topics

Linear Algebra

linear algebra (31)
matrix algebra (26)
matrix inverses (5)
determinants
Markov chains
Gauss-Jordan algebra
symbolic algebra

Discrete Mathematics

all topics in discrete mathematics (8)
sorting and parsing algorithms (2)
simulations and trace programs in discrete mathematics
finite mathematics
graph theory
game theory

Probability/Statistics

probability (9)
probability simulations (6)
central limit theorem in probability/statistics

Statistics

statistical analysis, finding mean, standard deviation, etc. (74)
statistics, all topics (17)
statistical graphics (5)
statistical simulations (4)
recursion (4)
hypothesis testing (3)
frequency distributions (3)
variability in random samples (3)
Monte Carlo methods (2)
statistics/data storage
scatter plots
law of averages
least squares
optimization

Other (Mathematics)

number theory (5)
phase plane analysis
conformal maps
numerical quadrature
data base management system (DBMS)

Other Subjects

programming (3)
operations research (2)
business and economics
college physics
assembly language
software engineering and documentation

(continued on next page)

*The number in parentheses indicates the number of times the topic was listed, if it was listed more than once.

Miscellaneous

simulations and demonstrations (19)
drill (9)
word processing (4)
any topic requiring dynamics and visualization (4)
any topic with heavy computation (4)
fostering exploration (3)
scientific word processing (2)
tutorials
finding patterns
logic
electronic spreadsheets
any algorithmic technique
communications (electronics networks, etc.)
term papers

APPENDIX 10. COMMENTS MADE IN RESPONSE TO QUESTION 7 OF PART II*

Comments Explaining "No" or "No opinion"

"Cannot" is a strong term; maybe some [skills] could be assessed better (easier, faster) by computer. (12)
I need more experience before I can answer this. (10)
No; generally everything can be assessed by paper-and-pencil tests. (8)
Enhanced, but not assessed. (8)
There probably are such topics, but none springs to mind. (6)
There are such topics, but not at the introductory college level. (4)
There are such topics, but not for standardized tests. (2)
Technically, no, but practically, yes (e.g., run 1,000 cases). (2)
Calculators, yes, but micros would add little. (2)
There is the problem of random punching of keys, rather than using concepts. (2)
Not in courses I have taught.
Sometimes, with some students.
Computer Assisted Instruction packages are not impressive.

Skills That Could Be Assessed Using Microcomputers

3-dimensional graphing and visualizing (9)
applied math, such as population models, etc. (6)
problems with huge data input (6)
estimation (5)
modeling; interpreting models; choosing among models (4)
logical thinking, argumentation (2)
graphing skills (2)
problem solving (2)
pattern recognition (2)
algorithmic development and use (2)
A computer can time students' reaction times and so can test, e.g., calculation speed. (2)
Using graphics, you can test understanding of functional properties and dependencies. (2)
determining the behavior of a system and the stability of underlying algorithms
ability to analyze mathematical results
overall organization; system or global reasoning
making predictions and checking hunches
curve fitting
using algorithms in numerical and statistical analysis
discrete-number crunching

Topics in Which Assessment Could Be by Microcomputers

numerical methods (2)
complex simulations
problems requiring iterative methods
dynamic processes
dynamic situations displayed in real time and tested interactively
limits
Gaussian elimination
linear programming

Further Comments

Symbolic manipulation packages can "filter out" manipulation skills to get at understanding of concepts. (3)
With computers you can ask more penetrating questions. (3)
Computers can be used to foster an experimental approach.

*The number in parentheses indicates the number of times the comment was made, if it was made more than once.

APPENDIX 11. PARTICIPATING INSTITUTIONS

Group I: Colleges Requiring College Board Achievement Test Scores of Prospective Students

Agnes Scott College, GA
Amherst College, MA
Antillian College, PR
Atlantic Union College, MA
Bates College, ME
Bayamon Central University, PR
Boston Collage, MA
Boston University, MA
Bryn Mawr College, PA
Bucknell University, PA
California Institute of Technology, CA
Campbell University, NC
Caribbean University College, PR
Clark University, MA
Colby College, ME
Colgate University, NY
Columbia University: Columbia College, NY
Cooper Union, NY
Dartmouth College, NH
Drexel University, PA
Duke University, NC
Elms College, MA
Franklin and Marshall College, PA
Georgetown University, DC
Hanover College, IN
Johns Hopkins University, MD
Lehigh University, PA
Lynchburg College, VA
Mary Baldwin College, VA
Massachusetts Institute of Technology, MA
Mount Holyoke College, MA
New Jersey Institute of Technology, NJ
North Carolina Central University, NC
Northwestern University, IL
Ohio State University: Newark Campus, OH
Oregon State University, OR
Philadelphia College of Pharmacy and Science, PA
Polytechnic University, NY
Principia College, IL
Quinnipiac College, CT
Reed College, OR
Rensselaer Polytechnic Institute, NY
Rice University, TX
Rutgers—The State University of New Jersey, NJ
St. Anselm College, NH
St. Mary's College, IN
St. Mary's College of California, CA
Southern University and Agricultural and Mechanical College, LA
Swarthmore College, PA
Technological College of the Municipality of San Juan, PR
Texas Lutheran College, TX
Union College, NY
University of Miami, FL
University of Michigan, MI
University of North Carolina at Chapel Hill, NC
University of Pennsylvania, PA
University of Puerto Rico: Cayey University College, PR
University of Puerto Rico: Humacao University College, PR
University of Puerto Rico: Mayaguez Campus, PR
University of Richmond, VA
University of Texas at Austin, TX
University of Virginia, VA
University of Wisconsin: Superior, WI
Vassar College, NY
Villanova University, PA
Virginia Polytechnic Institute and State University, VA
Washington and Jefferson College, PA
Washington and Lee University, VA
Webb Institute of Naval Architecture, NY
Wesleyan University, CT
Western Oregon State College, OR
Worcester Polytechnic Institute, MA

Group II: Colleges Not Requiring College Board Achievement Test Scores, but Receiving Such Scores from at Least 24 Prospective Students

Albion College, MI
American University, DC
Antioch College, OH
Azusa Pacific University, CA
Ball State University, IN
Beloit College, WI
Bradley University, IL
California State University: Chico, CA
California State University: Dominguez Hills, CA
Carleton College, MN
Catawba College, NC
Centre College, KY
Clarkson University, NY
College of Notre Dame of Maryland, MD
Colorado College, CO
Cornell College, IA
De Paul University, IL
Diablo Valley College, CA
Dickinson College, PA
Earlham College, IN
East Carolina University, NC
Eastern Michigan University, MI

Eastern Nazarene College, MA
Eckerd College, FL
Fairleigh Dickinson University: Florham-Madison Campus, NJ
Fairleigh Dickinson University: Rutherford Campus, NJ
Fitchburg State College, MA
Florida Southern College, FL
George Mason University, VA
Georgia Southern College, GA
Gettysburg College, PA
Glassboro State College, NJ
Gonzaga University, WA
Gordon College, MA
Gustavus Adolphus College, MN
Hampden-Sydney College, VA
Hawthorne College, NH
Illinois State University, IL
Indiana Institute of Technology, IN
Iowa State University, IA
John Carroll University, OH
Juniata College, PA
Kalamazoo College, MI
Kenyon College, OH
Knox College, IL
Lawrence University, WI
Lebanon Valley College, PA
Lehigh County Community College, PA
Lenoir-Rhyne College, NC
Liberty University, VA
Linfield College, OR
Louisiana State University, Baton Rouge, LA
Loyola University of Chicago, IL
Lyndon State College, VT
McMurry College, TX
Massachusetts Maritime Academy, MA
Merrimack College, MA
Mount Union College, OH
New Mexico State University, NM
Occidental College, CA
Oklahoma State University, OK
Point Loma Nazarene College, CA
Radford University, VA
Rhode Island College, RI
Rochester Institute of Technology, NY
Russell Sage College, NY
St. Francis College, PA
St. Joseph's University, PA
St. Mary's University, TX
Salisbury State College, MD
Shenandoah College and Conservatory, VA
Shippensburg University of Pennsylvania, PA
Sonoma State University, CA
State University of New York at Buffalo, NY
State University of New York College at Oneonta, NY
State University of New York Maritime College, NY
Syracuse University, NY
Texas A&M University, TX
Texas Woman's University, TX
Trenton State College, NJ
Trinity College, DC
Trinity College of Vermont, VT
Trinity University, TX
University of Arizona, AZ
University of Colorado at Denver, CO
University of Dallas, TX
University of Hartford, CT
University of Hawaii at Manoa, HI
University of Idaho, ID
University of Illinois at Chicago, IL
University of Louisville, KY
University of Maine at Farmington, ME
University of Massachusetts at Amherst, MA
University of Oklahoma, OK
University of Scranton, PA
University of Southern Maine, ME
University of Tennessee: Knoxville, TN
University of Utah, UT
University of Vermont and State Agricultural College, VT
Utah State University, UT
Virginia Military Institute, VA
Virginia Wesleyan College, VA
Washington State University, WA
West Virginia Wesleyan College, WV
Western Carolina University, NC
Western Michigan University, MI
Wilkes College, PA
Willamette University, OR
Wofford College, SC
Wright State University, OH
Youngstown State University, OH